Concentration

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The most startling development in concentration processes this past year would have to be the results obtained after magnetic treatment of aqueous systems[1]. Beneficial effects were reported in both flotation and thickening on an industrial scale following the application of a magnetic field to the pulp prior to processing. The physical forces controlling this phenomenon as yet remain unknown.

Gravity Concentration

The study of gravity separation techniques has received limited attention in recent years, but it is by no means outdated. The hydraulic concentrator installed at Hanna's Groveland Mine has lowered the silica content in their pellet feed by 2.6%[2]. This concentrator, processing 300 ltph, employs the principles of elutriation in a covered thickener to effect the separation.

In another study involving the combined efforts of the U.S.B.M. and the Dow Chemical Company, the use of heavy liquids on an industrial scale was investigated[3]. Generally, this technique has been limited to laboratory analysis because of the high cost of liquids and the difficulty encountered in their recovery for recycle. It was shown, however, that the heavy liquids, methylene bromide and tetrabromomethane, may be recovered effectively and that industrial use of this technique should be considered.

Magnetic and Electrostatic Separation

Direct reduction processes of low-grade manganiferous iron ore followed by grinding and magnetic separation of metallic iron have received attention recently[4,5]. This approach has been taken to effectively concentrate the metallic iron and reject the manganese values in the tailings. Iron concentrates containing greater than 90% iron at recoveries of 90% with rejections of manganese to the tailings of about 90% have been obtained[4]. High temperature phase relations involved in this process have also been investigated by X-ray diffraction studies[5].

Lawver, Wright, and Kohal[6] have obtained good iron recoveries on + 500 mesh material from Mesabi semi-taconites and oxidized taconite ores. They used a high-intensity wet magnetic separator capable of achieving a 20 kilogauss field.

An improvement of demagnetizing coils and magnetic flocculators has been described by Benson, Bartnik and Rose[7]. Besides improving the design of the equipment, optimum conditions of operation were established.

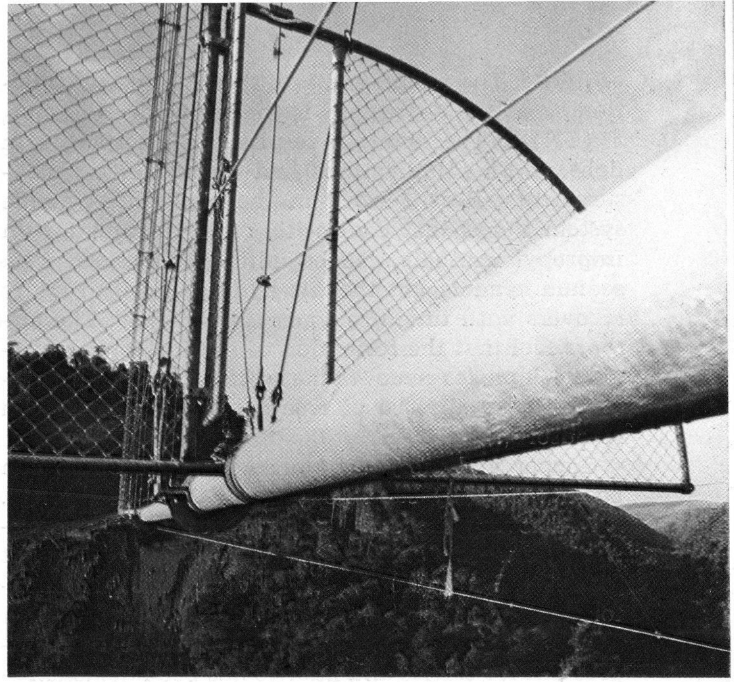
Finally, in the area of iron ore concentration, a high tension electrostatic technique has been used to produce a super concentrate containing less than 0.1% silica from a variety of magnetite and hematite ores[8].

The use of magnetic separation techniques outside the ferrous industry has been considered. Effective recovery of non-sulfide molybdenum and wolframite minerals from lean ores by high intensity wet magnetic separation has been demonstrated by Masoner[9]. Extensive pilot plant tests have established the important parameters which control this separation.

Flotation

Research in the area of iron ore flotation has been directed along three lines[10-14]. Lentz and Cronberg[10] have shown, both in the laboratory and in pilot plant tests, that ether amine and ether diamine collectors are more efficient than the conventional aliphatic primary amines. Iwasaki and Carlson[11] have studied how modification of corn starches, frequently used to depress hematite in cationic flotation systems, affects their adsorption of quartz and hematite.

Another technique for concentrating iron ore is that of agglomeration. Two recent studies indicate that this is technically feasible[12,13]. In the one case,



Savage River Pipeline. An annual 2.25 million tons of iron ore pour out of the wilderness of Tasmania through this 53-mile long pipeline.

iron oxide was agglomerated below its zpc using a fatty acid and was effectively separated from the apatite-containing gangue[13]. The economics of this process do not seem favorable at the present time.

Finally, the third method of treating iron ore, that of anionic flotation, has been investigated by Fuerstenau, Miller, and Harper[14]. Results obtained with potassium octyl hydroxamate were shown to be metallurgically and economically superior to those obtained with a conventionally used fatty acid with ores that are ground extremely fine.

The flotation of cassiterite from its ores has also been of great interest. Collins *et al.*[15] developed a process with a Cornish ore using a detailed reagent schedule; phosphonic acid was the collector. With a deslimed feed, high selectivity from sulfides, fluorite, chlorite, tourmaline, and iron oxide was obtained. In addition to this work, Arbiter and Hinn[16] have been issued a British patent for the use of alkyl sulfosuccinates and sulfosuccinamates as collectors for cassiterite.

Theoretical aspects of sulfide flotation have been studied recently. Fuerstenau, Kuhn, and Elgillani[17] presented evidence that the species which functions as collector in the pyrite-xanthate system is the oxidation product of xanthate, dixanthogen. Evidence which support the premise include oxidation potential measurements, electrokinetic measurements and infrared spectra. In the chalcocite-isopropyl xanthate system, Paterson and Salman[18] suggest that the species responsible for collection are cuprous xanthate and dixanthogen.

In the area of sulfide depression, Steininger[19] has shown that depression of pyrite and sphalerite may occur at neutral pH in the presence of copper slats when using a sulfhydryl collector. This observed depression was ascribed to the formation of basic copper-collector complexes.

Elgillani and Fuerstenau[20] have done an exhaustive study on the mechanism of cyanide depression of pyrite. The results indicate that the species functioning as the depressant is the ferrocyanide anion, $Fe(CN)_6^{-4}$. The flotation results are interpreted in light of Eh-pH diagrams and electrokinetic measurements. Recent work in the chalcocite-cyanide system shows that chalcocite, after treatment with isopropyl xanthate, can be initially depressed with sodium cyanide but that its hydrophobicity rapidly recovers with time if oxygen is available[21]. The authors feel that the formation of soluble copper-cyanide complexes removes the xanthate coating. However, in the absence of free cyanide, xanthate can re-adsorb.

Copper and molybdenum recovery at Chino can be increased by sand flotation of the mill tailing[22]. By removing the deleterious slimes, copper recoveries between 80 and 85% were effected in pilot plant studies without the use of additional collector.

The complex action of sodium silicate as a depressant for calcite and fluorite has been demonstrated[23]. Flotation results are interpreted from electrokinetic data and the solution chemistry of sodium silicate. This important work indicates that colloidal silica is the species principally responsible for calcite depression.

The flotation response of soluble salts has been studied by Roman, Fuerstenau and Seidel[24,25]. It is shown in these works that alkali halide salts carry a surface charge in brines, and the flotation behavior of these salts relative to this property is discussed. Solubility relationships, metal ion activation, and particle size effects are also presented.

Work on electronic color sorting has continued[26]. Gypsum may be concentrated effectively by this means. This technique, which operates best on closely sized material, employs a pneumatic ejection system. Difficulties encountered are those of sizing the ore and keeping it free from dust in order to accent color differences.

Another sorting device for the separation of quartz, limestone and silicate rocks is under development in California. After only fines removal, a reagent containing a fluorescent material is selectively adsorbed on the surface of one of the minerals. The fluorescent material is activated by ultra violet light and ejection is by hydraulic means[27].

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